Typographical effects by cathode ray tube typesetting systems

F. C. Holland

A few years ago typesetting machinery was made in quantity by only three major manufacturers, who supplied the greater part of the world's needs. Suddenly electronic engineering, and a trend towards printing methods requiring filmed typography to prepare the printing surfaces, has produced dramatic changes. Cast metal type has ceased to be the sole source of typography and is being partically replaced by photo typesetting systems.

As soon as this trend got under way a number of development engineers asked 'Why not utilize the fullest speed obtainable from modern electronics and do away with all the moving mechanical parts so far necessary to systems projecting light through master character negatives?' The answer is the cathode ray tube (CRT) image generator, and now several manufacturers are developing high-speed typesetting systems intended to operate as slave units under the control of computers.

Such systems can be extremely fast, versatile and provide high quality typography. But there are dangers about which I wish to speak. The dialogue mentioned earlier between printers and the typesetting machine manufacturers appears to be breaking up. Newcomers, specialists in electronic engineering, are busy making machinery to project type images and they may not be paying enough attention to the long established art of typography. I believe that the typesetting machine is of lesser importance than the end product—the typography—and many printers feel the same way. The machine should never be considered as an end in itself. If this is accepted then it is important for printers to understand the weaknesses as well as the strengths of any new and little-tried devices.

To show the differences between print and electronics, a system now being offered claims to be able to italicise roman type. What is obviously meant is that roman type can be electronically inclined from vertical to slanted, and this is a very different thing from italics.

This distinction is small, but supposing we find that what the electronics engineer believes is 'acceptable quality' is considerably different from what is really needed. Obviously, not only does the electronics engineer need to know about typography but the printer needs to know about such things as CRT character generation, and both need to know these things at the beginning of the development rather than later when it may be too late to avoid losses and disappointments.

Of the several variations possible there are two kinds of CRT system. Both have similar output or projector stages: the factors which determine the difference are to do with the input.

The direct system

This consists of a means to scan master negative character images with something akin to a television camera. The essence of this process is the conversion of a visible and physical image into a series of electrical signals. These signals can be produced by scanning the master images with a spot of light travelling at high speed across the face of a CRT in a series of parallel sweeps. This spot of light can be focused by conventional optics to reflect from, or be transmitted through, the type matrices depending on whether they are opaque or transparent. In either case the differential reflection or transmission of the flying spot of light can be detected by light-sensitive cells and electrical signals are generated.

Once the master images have been scanned into a sequential train of electrical signals, they can be used to drive another CRT, which can project from its face a reproduction of the original master on to light-sensitive film. Thus the selection, regeneration and projection of a type image can be done at high speed with no physically moving parts. By directing the scanner camera or CRT sequentially to one of many character images held in an array, characters may be selected according to a program to produce normal typesetting on film.

The indirect system

Having scanned the character images to produce electrical signals, it is possible to retain the signals in a memory system such as that used with electronic data processors. Thus, once scanning has been done, it need not be repeated and a typesetting machine could get its input signals direct from a memory store instead of from its own scanner. The relative merits of these two systems are not important to my theme, but all CRT typesetting devices, whether direct or indirect, create and project typographic images with a flying spot of light. This requires that each character image is reduced to, and later built up from, a number of small elements, rather as a half-tone illustration is composed of dots. Obviously the size of the picture elements (or the flying spot) relative to the size of the actual character is a prime factor in resolution. If an infinitely small spot of light is chosen, then pure facsimile reproduction is theoretically possible, whereas if a large spot is chosen, reproduction tends to be increasingly impure. Unfortunately the flying spot in a CRT is made small only with considerable difficulty and reduction below ·001″ is very difficult. Steering the spot in straight lines over the whole arc of the tube face and keeping the spot identical in size and shape during the movement is also a problem.

The size of the spot in a given system is directly related to the speed at which it runs and the size of the font, or array of master

images, used. The relation is such as to produce low quality if speed and versatility are given priority. Quality, speed and versatility will have to be traded, the one for the other, in a particularly troublesome way. For instance, in theory, to raise the quality of reproduction by two to one means that cost goes up by four to one, or the characters (font) must be reduced by four to one and speed will be reduced by four to one in both cases.

The most important thing in this new technique, for both user and maker of the equipment, is to agree on what is the *lowest* number of picture elements per character (or per inch of final projection area) that will produce the required typographic standards in the final printed result.

A view of CRT image generation

The first decision is the allocation of a particular number of flying spot sweeps to a character image. Arising out of this decision is the actual size of the character presented for scanning, because the number of scans has a fixed maximum for a given CRT.

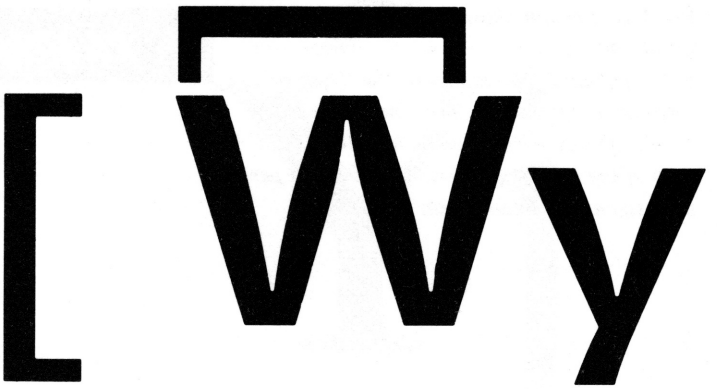
Typographical characters have unrelated shapes and the printer's range of required characters is much larger than one would suppose.

Somewhere between 100 and 150 lines per character seem to resolve type tolerably well. The ultimate threshold of mere identification of alphabet characters should not be deduced from a's and b's. The important and essential conditions are those where differentiation must be made between an inch mark and a double quote mark, between an apostrophe and an acute accent, between an italic and a roman comma or full point.

The problem of flying spot 'pick up' and 'drop out' is that certain characters will always have elements not quite parallel to the scan direction—italics and roman mixtures. The flying spot therefore must be small enough to allow arbitrary additions and losses to the image areas to be made without their being noticeable, for instance, between one serif and the next. The terms used in this technique are somewhat misleading. The number of scan tracks or sweeps used is frequently quoted as so many 'lines per inch'. In my opinion this is meaningless until the type size at the output stage is mentioned, so that the number of lines or picture elements per character body depth can be known. 1,000 lines per inch is about 150 lines per character in *12 pt*—it is 75 in 6 pt!

The ultimate objective for the manufacturer should be to preserve rather than destroy typographic quality. This can be done, but it will require the printer, or other potential purchaser, to press this need early, rather than later, in development programs.

Fig 1 illustrates how in an expanded bold fount the body depth, as shown by the square bracket, is some 15 per cent less than the width of a capital W. So that the area to be scanned in the fount is often not even a square

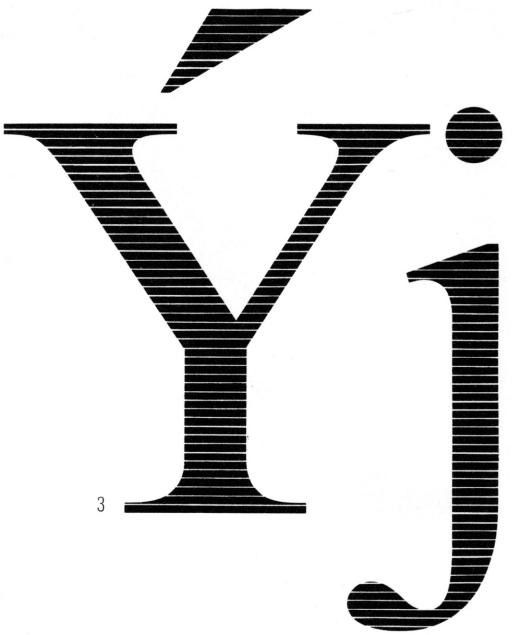


1

Fig 2 shows some typical characters in a common type face. The serifs limiting the apparent height of the characters are approximately .003" thick in the 12 pt size of this face and this means the ratio of serif thickness to body height is about 50 to 1. One might assume from this that the picture element, or size of flying spot, could not resolve such a narrow area of the image unless it was at least smaller itself. This predicates a flying spot size of substantially less than 1/50" or 2 per cent of the body depth just to reproduce in a degenerated way

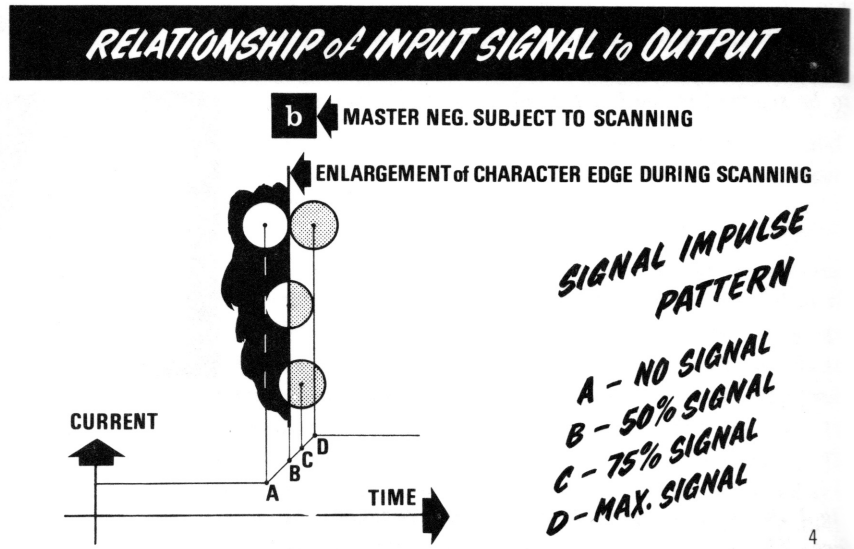
2

Fig 3 shows the same characters broken into 72 horizontal elements with a thickness of $1\frac{1}{2}$ per cent of the body depth. The scan direction is exactly parallel to the width of the characters and it is clearly seen how some of the picture elements contain areas where only portions of the element are true image. In the event of such areas being scanned by a flying spot some decision would be necessary to arrange which portions would be acceptable and which should be rejected. An arbitrary decision might be to accept areas more than 50 per cent true image, rejecting those of less than 50 per cent. If one did this then the scanning system would only register elements in each track where the signal strength exceeded 50 per cent



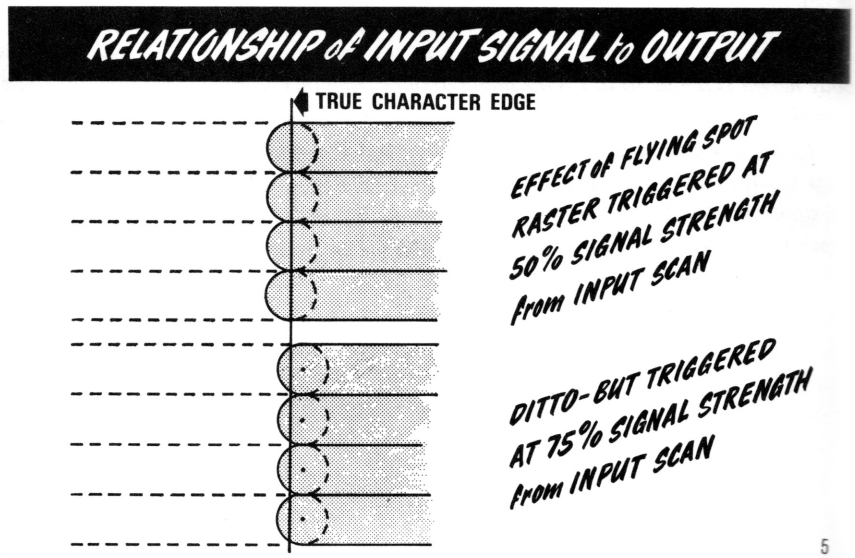
3

Fig 4 is a graph showing the way the electrical current would rise on the output side of the primary scan device as the flying spot approaches, crosses into the image area and finally passes beyond back into the 'dead' area of the character form. The 50 or 75 per cent signal acceptance can be seen



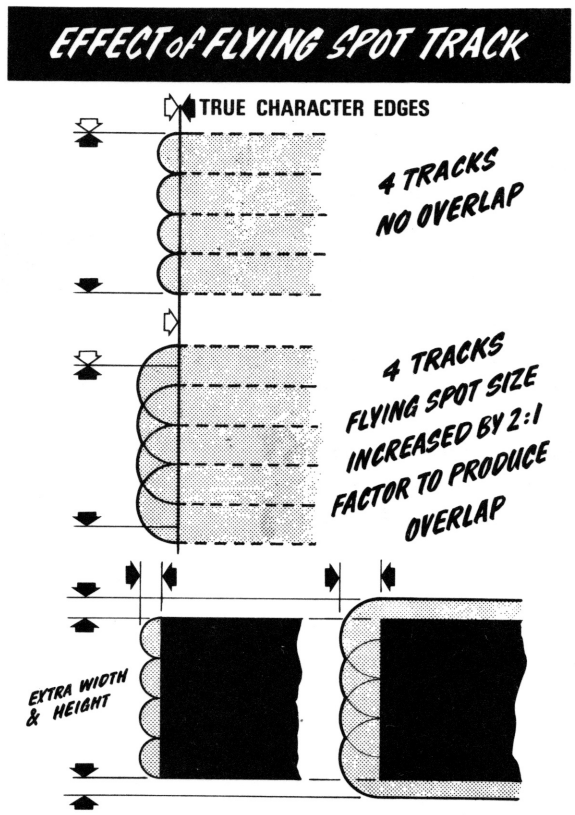
4

Fig 5 shows how by triggering the system to accept at 50 or 75 per cent, different effects would be achieved at the final output projection. 50 per cent acceptance will produce an enlargement of the final image by one half flying spot dimension at each image edge at right angles to the direction of the scan sweep. The 75 per cent acceptance only adds a quarter of a flying spot size to the real image



5

Fig 6 attempts to show how the flying spot movement can be deliberately overlapped on successive sweeps. This will then add not only to the character edges at 90° to the direction of scan, but will also add to the edges parallel to the scan movement

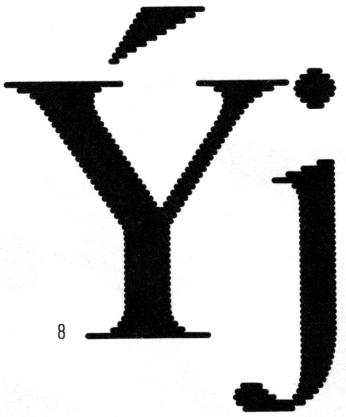


6

Fig 7 shows how a character projected from a CRT would appear if 72 flying spot sweeps are used to resolve the image. This is the best result that might be obtained for 72 sweeps and in practice it would be difficult to avoid conditions where the flying spot movement would not be exactly parallel to the serif and straight character forms. Where there was a departure from parallelism the character edges might arbitrarily be given extra flying spot sweeps or on the other hand might lose them over part of normal straight edges. This simulation and all the following ones represent signal acceptance rated at 50 per cent

7

Fig 8 is the same as Fig 7 but illustrates scanning in the other direction

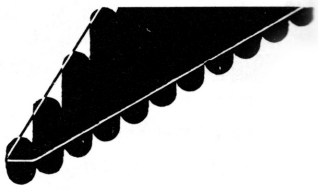


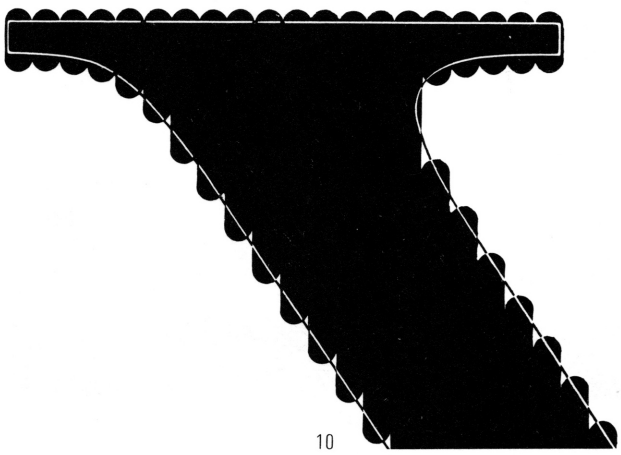
8

Fig 9 shows the projected output overlaid with the actual original type form and illustrates the growth of the image due to the flying spot tracks where signals are accepted at 50 per cent

9

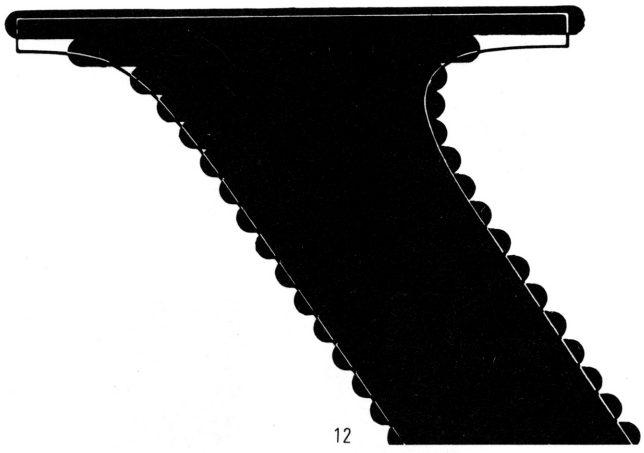
Fig 10 shows an enlarged view of Fig 9; and Fig 11 is the same as Fig 9 but scanned the other way, with Fig 12 being an enlarged view of Fig 11. Note the typical enlargement compared with Fig 10





10

11



12

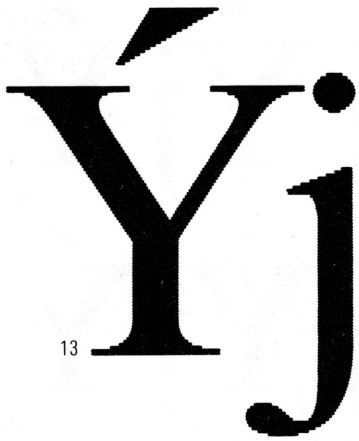


Fig 13 illustrates the improved effects obtained by doubling the scan sweeps to 144

Fig 14 is the same as Fig 13 but scanned the other way

Fig 15 shows 216 scan sweeps

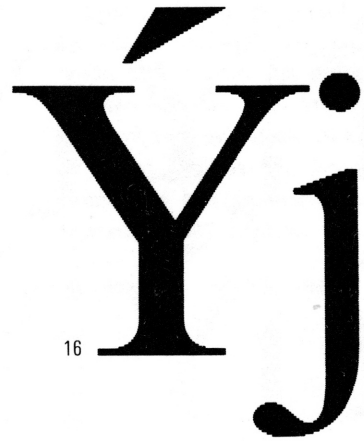


Fig 16 shows scanning at 216 sweeps of the flying spot in the other direction from Fig 15

Fig 17 illustrates the almost pure resolution of 288 scan sweeps

Fig 18 shows the same effect as Fig 17 but scanned in the other direction. Note how the differences between Figs 17 and 18 are minimal

Fig 19 is a display of all the previous projected images showing an unscanned control at the top left corner. The other scanned characters are shown—reading from left to right in succeeding rows from the top as:— control, 72 vertical scan, 72 horizontal, 216 horizontal, 144 horizontal, 144 vertical, 288 vertical, 288 horizontal and 216 vertical

19

Fig 20 shows a piece of film that was prepared with images of the control unscanned character form followed by 72 sweeps scanned vertically and horizontally. This film was used to print out a lithographic plate

20

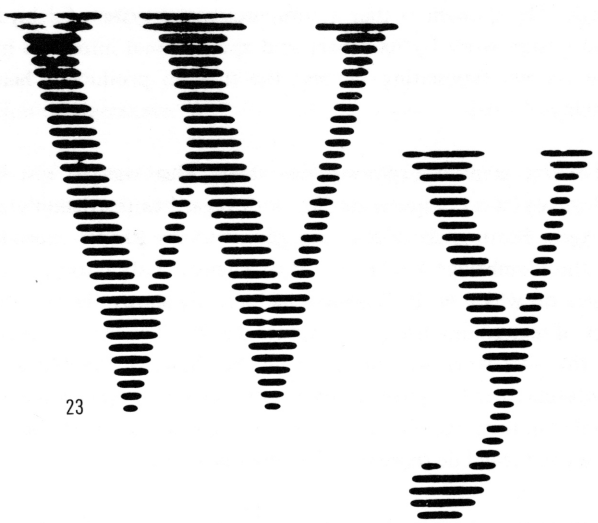
Fig 21 shows the actual lithographic proof from the film in Fig 20. This well illustrates the effects of ink spread and paper surface texture in modifying the original scanned character forms. However, the thickening effects of the flying spot are obvious in the serifs of the vertically scanned character

21

Fig 22 is a lithographic proof from film prepared similarly to that in Fig 19. The thickening of the serifs and other elements can be taken as an indication of the direction of the scan, as the thickening is always most pronounced at 90° to the scanning

22

Fig 23 is a piece of film actually taken from a CRT in which flying spot 'drop out' can be seen. Because the scan was not parallel to the base line of the type, one sweep of the top right serif of the W has been rejected or 'dropped out'



23

Fig 24 shows in a more obvious fashion some of the effects of scanning 'drop out' and 'pick up'. This image was scanned vertically at approximately 50 sweeps (per body depth). The scanning was not parallel to the main ascenders and the effects of flying spot sweeps being accepted or rejected half way down a character stroke are very obvious

24